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WATER QUALITY CONTROL STUDY OF THE
YELLOW JACKET PROJECT, WHITE AND
YAMPA RIVER BASINS, COLORADO

Federal Water Pollution Control Administration
Denver, Colorado

January 1966

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WATER QUALITY CONTROL STUDY

of the

YELLOWJACKET PROJECT



LOCATION MAP

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Region VIII
Denver, Colorado

January 1966

WATER QUALITY CONTROL STUDY
YELLOW JACKET PROJECT
WHITE AND YAMPA RIVER BASINS
COLORADO

ABSTRACT

A survey has been made of the Yellow Jacket Project which discloses that there is no apparent need for storage for streamflow regulation for the purpose of water quality control. This conclusion is based on results of economic and demographic studies which indicate that future waste loadings will not impair water quality for present and projected water users in the area.

Prepared at the request of and in cooperation with the
Bureau of Reclamation, Region 4, U. S. Department of the
Interior, Salt Lake City, Utah

U. S. Department of Health, Education, and Welfare
Federal Water Pollution Control Administration
Region VIII
Denver, Colorado

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I. INTRODUCTION

Request and Authority

The Bureau of Reclamation, Region 4, Department of the Interior, in a letter dated August 14, 1962, requested the Public Health Service, Department of Health, Education, and Welfare, to participate in the water quality control aspects of the Bureau's planning for the Yellow Jacket Project as set forth in the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.) The water quality control activities formerly conducted by the Public Health Service have been transferred to the Federal Water Pollution Control Administration by P. L. 89-234.

Purpose and Scope

General objectives of this study are to assess the probable effects of the proposed project on water quality in local streams and reservoirs; to ascertain the benefits or harm resulting from changes in water quality; to assess the suitability of the water for proposed water uses; and to determine the need for and value of storage for regulation of streamflow for the purpose of water quality control. The study covers Rio Blanco, Moffat, and Routt Counties in northwest Colorado. The need for streamflow regulation was studied not only for the present conditions, but also for anticipated future conditions to the year 2065.

Since this study has been made in advance of any comprehensive study of the Colorado River Basin, the findings presented are preliminary and subject to revision upon completion of comprehensive studies for water supply and water quality management in the Colorado River Basin.

Acknowledgments

The assistance and cooperation of many state and federal agencies and individuals are gratefully acknowledged by the Federal Water Pollution Control Administration. Particular appreciation is expressed to the following for data and information furnished by their staff members:

U. S. Bureau of Reclamation, Region 4
Salt Lake City, Utah
Project Office
Grand Junction, Colorado

Colorado State Department of Public Health
Denver, Colorado

U. S. Department of Agriculture
River Basin Survey Field Party
Denver, Colorado

U. S. Geological Survey
Water Resources Division
Denver, Colorado

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The Bureau of Reclamation's Yellow Jacket Project is located in northwestern Colorado in Rio Blanco, Routt, and Moffat Counties and will provide supplemental and full service irrigation water for lands in the White and Yampa River Basins. High runoff from spring snowmelts will be impounded in the proposed Lost Park Reservoir in the White River Basin and Thornburg Reservoir in the Yampa River Basin.
2. The Project lands are located in the Yampa and the White River Basins. The lands in the Yampa Basin are semiarid and lie 20 miles north of Meeker. This portion of the Project is primarily within the Milk Creek watershed which parallels Colorado Highway 13 and 789. The portion of the Project within the White River Basin is also semiarid and lies just east and south of Meeker.
3. This is a sparsely populated, somewhat isolated area whose economy has historically been based upon sheep, cattle, and coal. In the past twenty years petroleum has surged into prominence as the most important product of the area but is now declining. None of the economic activities of the area are large labor users and population growth has been only moderate.
4. Irrigation is presently the largest water user in the study area. Waste discharges are presently being contributed to the Yampa River by Craig and in the White River by Meeker and Rangely after varying degrees of treatment. A high degree of mineralization (45% increase in loading) of the otherwise good quality White River water is being caused by Meeker Spring four miles east of Meeker.
5. Project water used for irrigation in the Yampa River Basin will have a flow weighted mean total dissolved solids (TDS) concentration of 256 mg/l while the water used in the White River Basin will have a flow weighted mean TDS concentration of 160 mg/l.

Conclusions

1. Future growth will stem from development of the area's abundant mineral fuel resources. A resurgence in coal mining is already taking place; oil production, although declining, is likely to be extended to the year 2000 by use of water flooding; uranium mining and processing, dormant for the present, will likely revive in 15 or 20 years; shale oil development in the adjacent Colorado River Valley could be a major factor in population growth. The recreation industry is growing rapidly and will be of major importance in the more immediate future of the area.

2. Under project conditions, considering only a one to one salt balance, the TDS will increase in the White River near Watson from 439 mg/l to 469 mg/l; in the Yampa River at Maybell, Colorado, from 139 mg/l to 140 mg/l; and the Green River near Ouray, Utah, from 392 mg/l to 396 mg/l. When leaching of native salts from irrigated lands is considered, in addition to the one to one salt balance, the TDS will increase in the White River near Watson, Utah, from 439 mg/l to 533 mg/l; in the Yampa River at Maybell, Colorado, from 139 mg/l to 147 mg/l; and in the Green River near Ouray, Utah, from 392 mg/l to 405 mg/l.
3. Since hardness is a constituent of TDS, the hardness in the White River at Rangely, Colorado is also expected to increase. Under a one to one salt balance the hardness increase will be 14 mg/l as CaCO_3 and result in a present annual damage to Rangely residents of \$400 a year and of \$1,000 in the year 2065. When leaching of native salts is considered, in addition to the one to one salt balance, the hardness increase is projected to be 43 mg/l as CaCO_3 . This increase will cause present damages of \$1,300 a year and \$3,400 a year in 2065.
4. By excluding the mineralized flow from Meeker Spring, the reduction in the TDS loading to surface waters in the project area would be 58,000 tons per year. This reduction in dissolved solids approximates the total projected TDS loading from the Project resulting from the leaching of native salts. However, due to the water loss caused by the Yellow Jacket Project, a 3 mg/l increase in concentration at Ouray, Utah, is projected for these conditions. With the exclusion of the spring, an 11 mg/l reduction in hardness is expected at Rangely, Colorado, which would be a savings of \$300 a year in 1965 and \$900 a year in 2065 to the residents of the area.
5. With adequate waste treatment facilities for the towns of Meeker, Craig, and Steamboat Springs, postproject streamflows are sufficient to assimilate the projected waste loads from these population centers.
6. Based on information available, no need is foreseen at this time for inclusion of storage in the project reservoirs for regulation of streamflow for the purpose of water quality control.

III. PROJECT DESCRIPTION

The Yellow Jacket Project is a multipurpose development which has as its primary purpose the providing of irrigation, municipal, and industrial waters. High quality municipal and industrial (M&I) water will be provided to the expected oil shale developers. The Project is divided into two independent portions with the major portion lying in the White River Basin near Meeker, Colorado, and the remaining portion lying north of Meeker in the Milk Creek area, a part of the Yampa River Basin. The principal features of the Project are shown on Figure 1 at the end of the report.

The Project features in the White River area are as follows:

1. Lost Park Reservoir, with a capacity of 22,500 acre-feet (AF), is located at an elevation of 8,200 feet on Lost Creek, a tributary of the White River. The reservoir is four miles from the mouth of Lost Creek which itself is nine miles upstream from Buford. In addition to Lost Creek runoff, water to be impounded will also be diverted from the South Fork of the Williams Fork River Basin by means of a system of collection canals, and will be collected in the Lost Creek Basin. This reservoir will discharge into the North Fork during irrigation season.
2. Ripple Dam and Reservoir, with a capacity of 20,000 AF, is located on the North Fork of the White River about eight miles upstream from Lost Creek. Impounded waters in this reservoir will be released in conjunction with Lost Park Reservoir and will be diverted into the Yellow Jacket Canal.
3. The Yellow Jacket Canal has a length of 38 miles and initial capacity of 500 cubic feet per second (cfs). This canal transports natural flows and the impounded flows of Lost Park Reservoir from a point five miles above Buford to lands north of the White River and to Josephine Basin Canal. The Yellow Jacket Canal terminates north of Meeker.
4. Josephine Basin Canal has a length of 40.5 miles and an initial capacity of 300 cfs. It diverts water from the Yellow Jacket Canal near Buford and serves some lands north of the White River then crosses the River to serve lands south of the White River. The Canal terminates six miles southwest of Meeker.

The proposed Project features in the Yampa River Basin are as follows:

1. The Thornburg Reservoir has a capacity of 20,000 AF and has an elevation of 6,800 feet. It is located 16 miles northeast of Meeker on Milk Creek, a tributary to the Yampa River.

2. The Milk Creek Canal is 21 miles long and has an initial capacity of 90 cfs. It diverts natural and impounded flows from Milk Creek three miles below Thornburg Reservoir. This canal serves agricultural lands by means of subordinant laterals.

Surplus winter runoff and spring snowmelts will provide the impounded water used by the Project.

The full service and supplemental irrigation water will be supplied by direct flow from the natural watercourse and from impoundments in the nearby mountains. In the White River area supplemental service will be provided to 2,000 acres while full service will be provided to 15,740 acres. In the Milk Creek area supplemental service will be provided to 1,690 acres while full service will be provided to 4,180 acres.

IV. STUDY AREA DESCRIPTION

The Yellow Jacket Project is in northwestern Colorado near the town of Meeker and lies in the counties of Rio Blanco and Moffat. Meeker and Craig, Colorado are the main population centers concerned with the Project. Rangely, Colorado, located 60 miles below Meeker on the White River, is the only other community which could be associated in Project activities. Meeker is on State Routes 13 and 789 midway between Rifle, which is on U. S. Routes 24 and 6, and Craig, which is on U. S. Route 40. These are the main year-around access routes to Meeker along with State Route 64, which proceeds northwest to join U. S. Route 40. There is no rail transportation; however, Meeker has facilities for small aircraft.

The Project lands are located in the Yampa and the White River Basins. The lands in the Yampa Basin are semiarid and lie 20 miles north of Meeker. This portion of the Project is primarily within the Milk Creek watershed which parallels Colorado Highway 13 and 789. The portion of the Project within the White River Basin is also semiarid and lies east and south of Meeker.

Some of the Project area receiving irrigation water lies on broken terrain where relatively flat areas are meshed with steep eroded valleys or gulches. Other Project lands are on long gentle slopes between the hills and the rivers. These lands are primarily suited for growing fodder and grazing livestock.

Agriculture is one of the primary industries of the area along with exploitation of subsurface energy-producing minerals.

The watershed varies in elevation from 7,000 to 12,000 feet. This area is primarily tree covered and lies within Routt and White River National Forests. The agricultural area in the White River area ranges in elevation from 6,400 to 7,000 feet while the lands in the Milk Creek area vary from 6,200 to 6,800 feet.

Precipitation on the Project irrigation lands is about 16 inches a year while the precipitation in the watershed areas ranges from 20 to 40 inches a year. Temperature records at Meeker indicate 102 days a year above freezing and a 132-day growing season for crops raised in the area.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water

Meeker is the only major community within the Project area. The town takes water from the White River 11 miles upstream, and the water is given filtration and disinfection. The Meeker plant provides water for 575 connections while rural residents in the Project area have private wells for their water supply. Rangely, Colorado, which is the only community downstream from the portion of the Project in the White River Basin, takes its domestic water from the White River and gives it filtration and disinfection. The Rangely plant is adequately providing the needs of the community, and no shortage problems are foreseen. Craig, Colorado is the only other town in the vicinity of the Yellow Jacket Project; however, since it lies above the proposed Project development, the Project should have no effect upon its water supply.

The State of Colorado has record of about 40 wells in the Project area. Most of these wells are used for stock watering, irrigation, or domestic supplies. These wells range in depth from 20 to 200 feet and yield from 1 to 50 gallons per minute (gpm). Records also show an industrial well at a depth of 7,026 feet with a yield of 615 gpm. Further east of Meeker there are several similar wells tapping the deep aquifer for the oil industry.

Discharge from the White River is exceptional in its consistency of flow which is verified by the flow duration curves shown in Figure 2. For example, 40% of the time the flow is equal to or greater than 425 cfs, while 99% of the time the flow is equal to or greater than 225 cfs.* The curves compare the White River near Meeker and the typically western Yampa River near Maybell, Colorado. The White River is a reliable source of water; therefore, provisions are being investigated by the Bureau of Reclamation to supply some of this water to the shale oil developers.

Quality of Water

The towns of Meeker and Craig take their water supply from the White and Yampa Rivers, respectively, near the mountains, and the quality is relatively good as reflected by an average TDS of 277 mg/l for Meeker and 260 mg/l for Craig. Rangely also takes its municipal water from the White River, which is 80 miles from the mountainous watershed and where the average TDS is 515 mg/l.

*These data are from an unpublished Geological Survey professional paper.

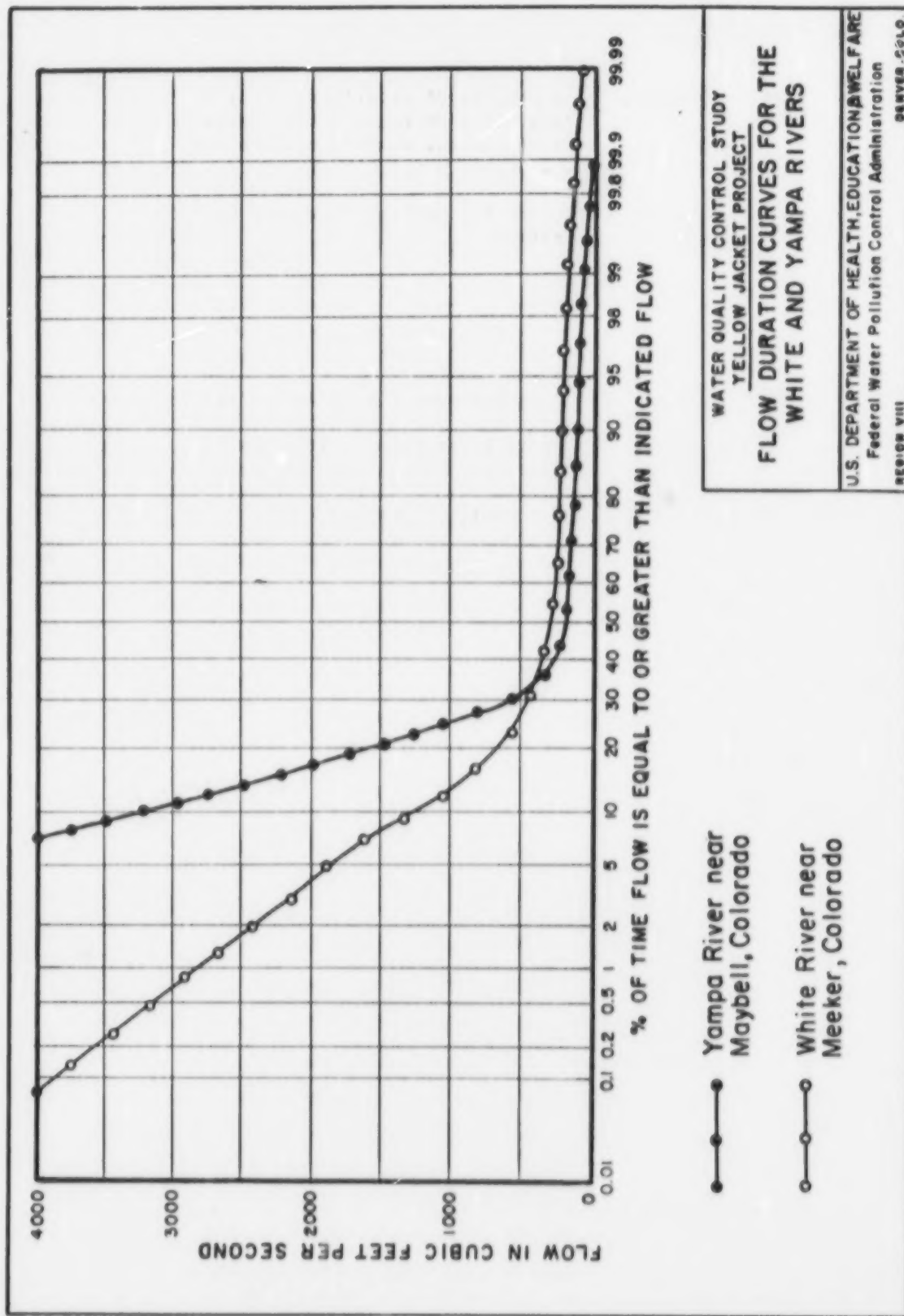


FIGURE 2

The water quality parameters of significance for irrigation are the mineral ion concentrations; therefore, total dissolved solids will be used as representative of mineral quality. Table I is a compilation of flow and TDS data for stations sampled by the Bureau of Reclamation in the Yellow Jacket area. The maximum and minimum flow and TDS concentrations are given along with the average flow and the flow weighted means of the TDS concentration.

Figure 3 shows the TDS pickup on a tons-per-year basis in the White River as the water leaves the mountains and enters the plains. The polluting effect of Meeker Spring is readily seen from the figure.

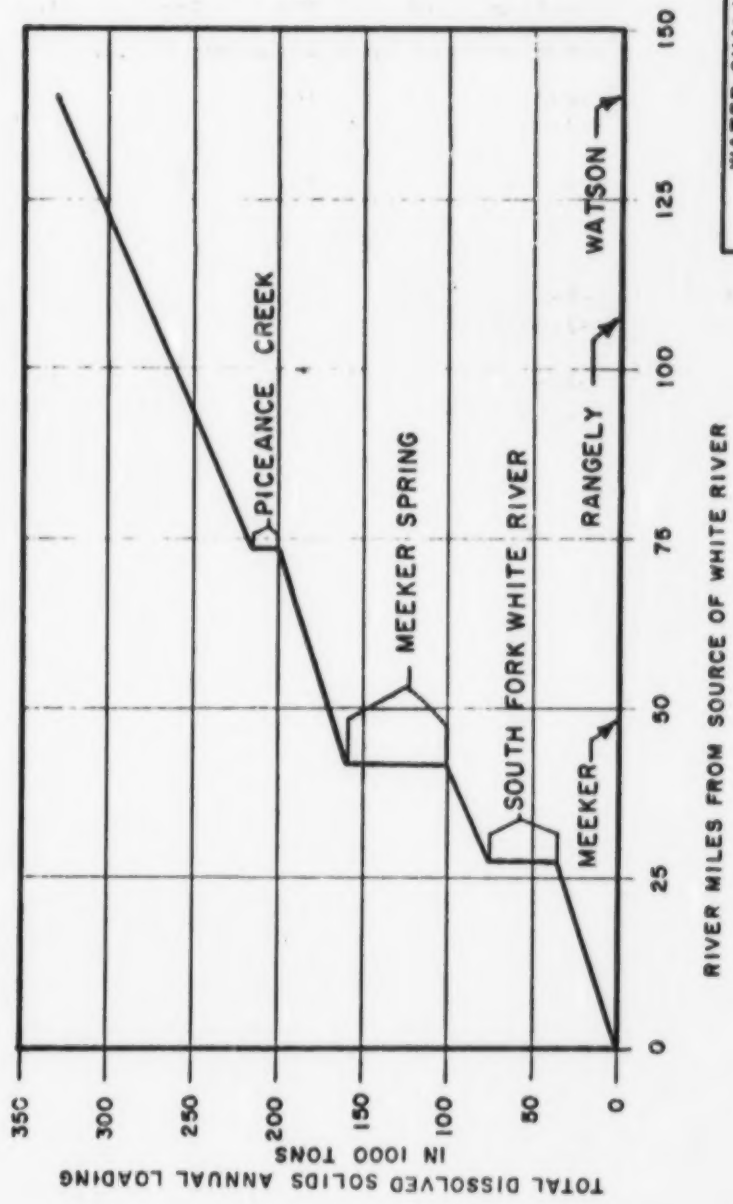
Water used for irrigation in the Yampa Basin comes from Thornburg Reservoir having a flow weighted mean TDS of 256 mg/l. The water used for irrigation in the White River Basin will consist of impoundments in Lost Park Reservoir and White River flows. Stored water in Lost Park Reservoir will be released to the White River and mixed with the normal flow and yield a flow weighted mean TDS of approximately 160 mg/l at the head gate of Josephine Canal.

TABLE I

FLows AND TOTAL DISSOLVED SOLIDS CONCENTRATIONS
FOR STREAMS IN THE YELLOW JACKET PROJECT AREA

Field Location	Sampling Period	Number of Samples	Mean* TDS mg/l	Extreme TDS-mg/l	Avg. Flow cfs	Extreme Flow-cfs
White River at USGS Gage near Bufford, Colo.	5-8-62 9-3-64	25	162	255 104	286	1210 110
South Fork White River at USGS Gage at Bufford, Colo.	2-15-64 9-3-64	7	144	195 107	189	560 85
White River at USGS Gage below Meeker, Colo.	5-8-62 9-2-64	26	344	689 189	600	2620 250
Lost Creek at Mouth Near Bufford, Colo.	6-24-64 9-3-64	2	126	293 109	11	20 2
Milk Creek at USGS Gage near Thornburgh, Colo.	5-9-62 9-3-64	21	256	745 173	37	350 0.5
Milk Creek near Axial, Colo.	5-12-64 9-3-64	4	481	1660 300	20	50 17

* Flow weighted mean



WATER QUALITY CONTROL STUDY
YAMPA AND WHITE RIVER BASINS

ANNUAL TOTAL DISSOLVED SOLIDS
LOADING ON THE WHITE RIVER

DEPARTMENT OF HEALTH EDUCATION & WELFARE
Federal Water Pollution Control Administration
REGION VIII
DENVER, COLO.

FIGURE 3

VI. THE ECONOMY

The Continental Divide is the eastern boundary of the study area and this portion of the area is quite mountainous. The balance of the area is mostly a vast, high plateau sloping down toward the west with elevation ranging from 5,000 to 12,000 feet. This plateau is intersected and cut up by two river systems, the Yampa River flows north and then west through the eastern and northern portion of the area and the White River which also flows east to west draining the southern portion of the study area. Both flow into the Green River just east of the study area in Utah.

The area encompassed by this study is the northwest corner of the state of Colorado comprising the three counties of Moffat, Rio Blanco, and Routt. There are numerous small towns in the area, the most important of which are Craig (1965 population 4,400) located on the Yampa River near the center of the area, Steamboat Springs (1965 population 1,900) upstream on the Yampa River in the eastern part of the area, Meeker (1965 population 1,655) on the White River in the south central section of the area, and Rangely (1965 population 1,700) downstream on the White River near the Utah border which is the western boundary of the study area. These towns were founded as trade and service centers for the developing livestock industry in the last quarter of the nineteenth century. Rangely and Craig have also become centers of mining activity.

Present Economic Activity

Agriculture is the most important economic activity in the area in terms of employment, and second only to petroleum as measured by value of product. Eighteen percent of the labor force of the area works at agricultural jobs, a decline from 26 percent in 1950 and 33 percent in 1940. The relative dominance of agriculture in the study area is illustrated by a comparison of employment with the State of Colorado and the United States in Figure 4. (The change-over time is seen in Figure 5.)

Livestock production is the major agricultural activity. In 1959, when the total value of all farm products sold was \$14,089,464, livestock and livestock products comprised 80% of this total, the value of all crops sold only 20%. In addition, the value of livestock and livestock products had increased 20% over the preceding ten years while the value of crops sold had declined 4% in the same period. In 1959, the value of cattle and calves sold was double that of sheep and lambs. Ten years earlier they had been about equal.

A look at the general pattern of land use (Figure 6) shows only one-third of the total land area in farms. Nearly two million acres (88 percent of the land in farms) is utilized as grazing land. One hundred fifty four thousand acres are dry farmed and only 82,000 acres are irrigated. The major crops are:

Figure 4

Industry Group of Employed Persons Comparison of Study Area, Colorado, and United States

1960

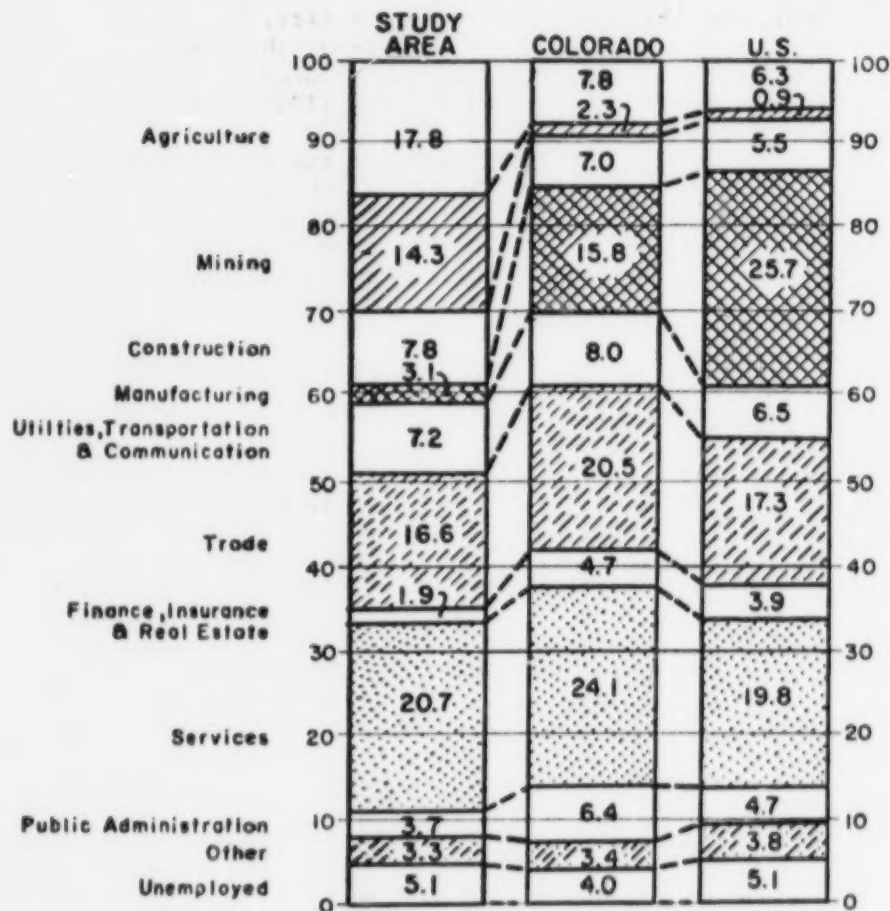


Figure 5
EMPLOYMENT TRENDS
 by Industry
 1940-1960

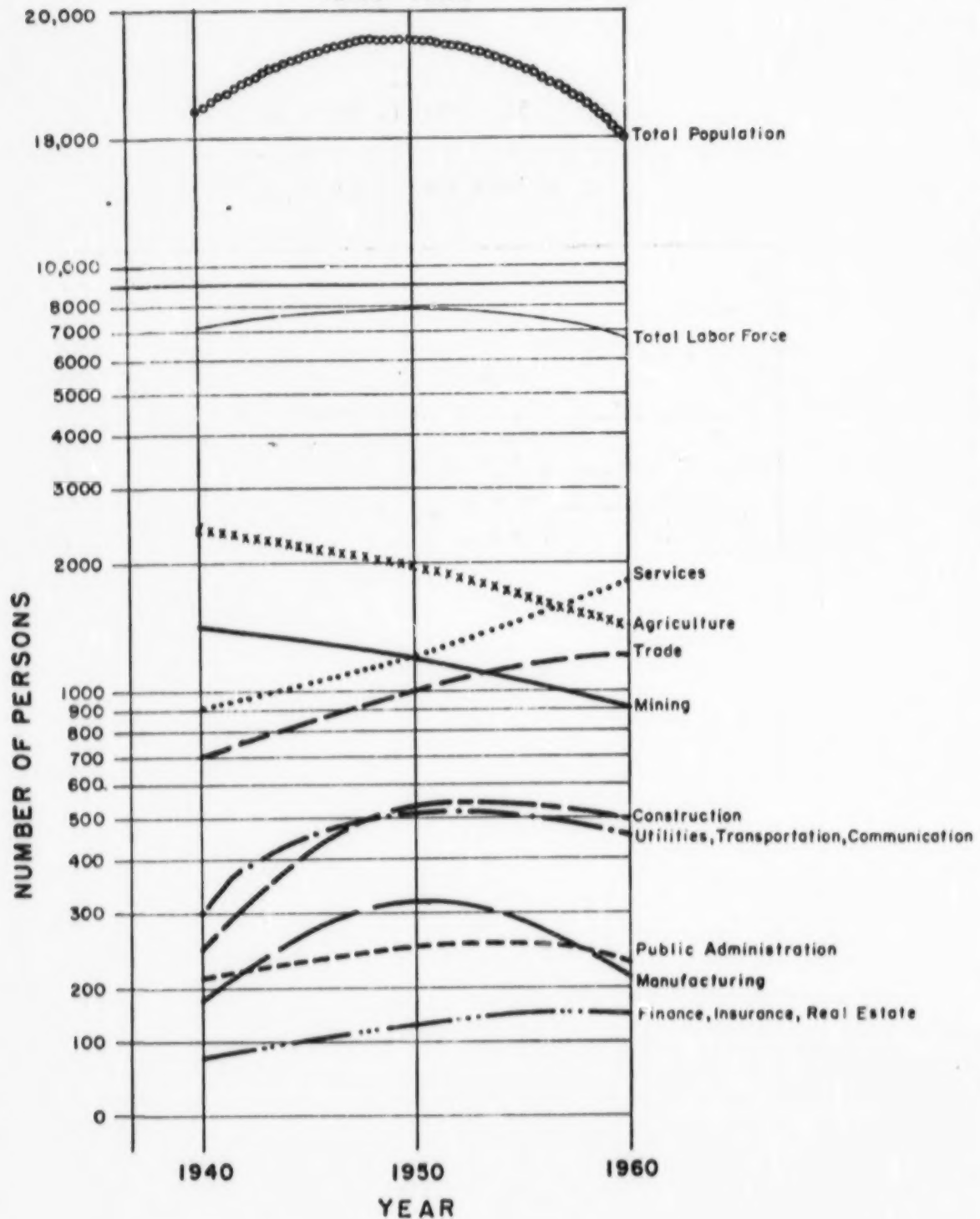
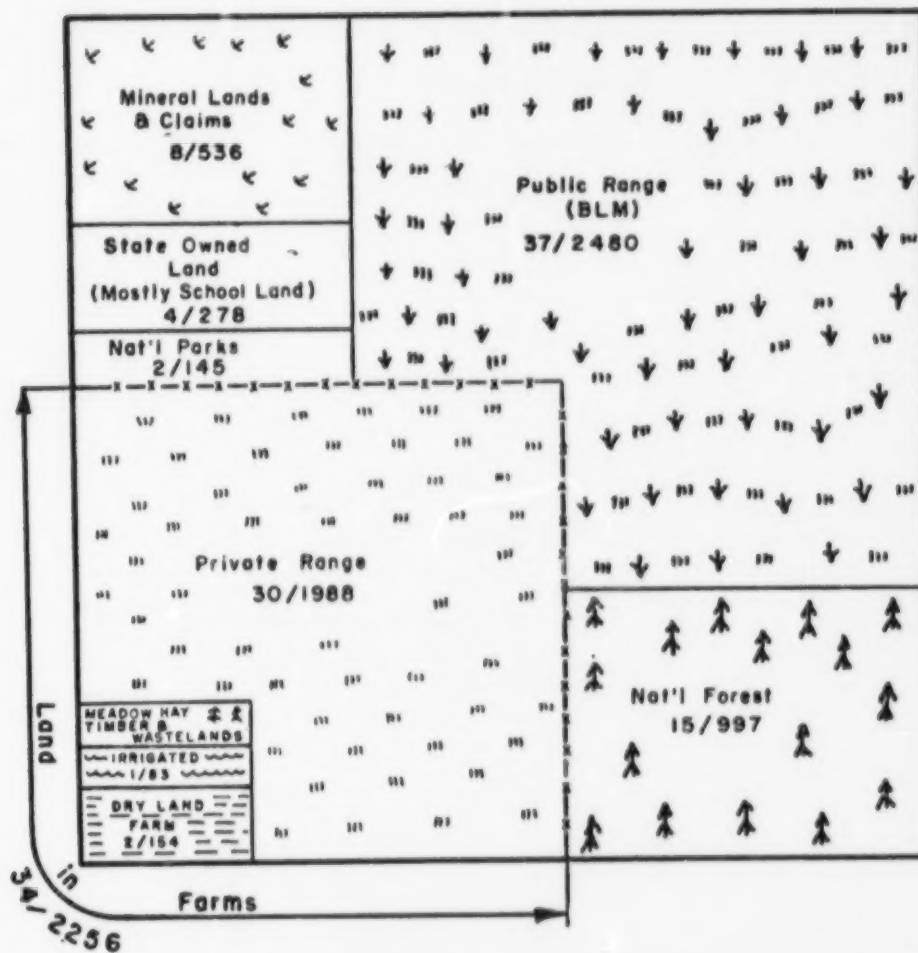


Figure 6

General Pattern of Land Use

KEY

30/1988 is 30% of
land area which is 1,988,000 acres
total land area is 6,622,000 acres



Hay	86,531 acres
Winter Wheat	41,582 acres
Barley	16,384 acres
Spring Wheat	7,969 acres

An additional two and one-half million acres of public land is in grazing districts managed by the Bureau of Land Management. There are nearly a million acres of national forest in the area.

The average value per acre of farms has increased from \$18.61 in 1949 to \$20.05 in 1959. At the same time the average value per farm has grown from \$33,621 to \$74,831, which in part reflects the increasing size of farms.

Mining employs 14 percent of the workers of the area, a share of the total labor force that has changed little in the past 20 years. This, as Figure 4 clearly demonstrates, is a disproportionately large share of workers in this industry. In terms of value of product, mining looms even larger and is one of the most important activities in this north-western corner of Colorado.

The most important mining activity is production of oil. This region produces about 55 percent of the petroleum produced in the state. Oil production began in 1919 and as the following table shows, production surged upward following development of the deep wells of the Rangely Field after 1946, reached a peak in 1956 and has followed a declining trend since.

Oil Production (barrels)

<u>1940</u>	<u>1950</u>	<u>1956</u>	<u>1960</u>	<u>1964</u>
1,204,826	22,688,887	31,768,920	21,974,759	19,046,263

It is likely that this declining trend in production will continue as the oil pools are exhausted. Exploration for new oil fields in the area has declined in recent years and the probability of major new discoveries here appear slight, although the interindustry study of the Green River Subbasin, made by the Associated Rocky Mountain Universities for the U. S. Public Health Service, projects an increase in oil production for the Green River Basin (of which the study area is a part) of 4.9 percent over 1960, by 1965, 41 percent by 1980 and 113.5 percent by 2010. In 1964, 35 new oil wells were drilled, but during the same time 63 wells were plugged and abandoned. One important development that will extend the life of this industry is the recharging of oil bearing sands with gas and water. At the Rangely field 38.9 million barrels of water were used for this purpose in 1960. It has been estimated that this water flooding operation will increase the lifetime production of the Rangely field from about 300 million barrels to about 700 million barrels and could extend the life of the field by 30 years to the year 2000. Water used is White River water and ground water obtained as part of the oil well operations.

There is only one oil refinery in the area, that at Rangely. Its 1960 through-put was 120,000 barrels, less than one half of one percent of the oil produced in the area. Hence, more than 99 percent of the oil is exported outside the area--mostly to refineries at Salt Lake City, Utah, and Sinclair, Wyoming. All the major fields in the area tie into the double pipeline to Salt Lake City or the central Wyoming pipeline. This reduces the probability of more refineries being built in the area or expansion of the existing one, which had, in fact, suspended operation in 1965.

The output of natural gas which is generally a joint product with crude oil has varied with the production of oil. In 1960, the output figure was 65,668,473 Mcf (thousand cubic feet). A greater amount of this gas, however, is finding economic use. In 1952, only 2.1 percent of the gas produced was sold, 3 percent was used to repressure oil wells, 18 percent to drive pump motors and 75 percent was vented unused into the atmosphere. By contrast in 1960, 51 percent was sold, 33 percent used to repressure oil wells, 13 percent used as fuel for pumping motors and only 3 percent released into the air. This is still a smaller utilization than of gas produced elsewhere in the state. This area was responsible for 43.3 percent of the gas produced in the state in 1964, but only 26.4 percent of gas sales.

The second most important mining activity in this area is coal mining. Coal mining generally has been a declining industry in recent years. However, it is showing signs of resurgence in the study area.

Coal Production (tons)

<u>1940</u>	<u>1950</u>	<u>1960</u>	<u>1963</u>	<u>1964</u>
973,492	998,367	606,614	951,700	1,081,864

The value of the 1964 production was \$5,495,869. The market is primarily to public utilities with most of the coal from the area being shipped by railroad to Denver. The domestic and commercial markets are very small. The coal is exclusively of the bituminous and sub-bituminous variety, with area reserves estimated at 20 billion tons. Most of the current production is from strip mines. The construction of a large REA power-plant at Hayden, Colorado, which was opened for operation in June 1965, is expected to double the coal production in the area. The Chief Coal Mine Inspector for the State of Colorado foresees a tripling of production in the next ten years. Further in the future and further into the realm of speculation is the possibility of construction of a slurry line to the west coast. This would greatly expand the potential market for coal from this area. It would also greatly increase the water requirement of the industry.

The third major mineral product of the area in the past few years, also an energy mineral, has been uranium. The mining and milling operation at Maybell, Colorado, produced about 600,000 pounds of uranium oxide in

1960 with a value of \$4,800,000. The ore mineral in the area contains a very low percentage of uranium oxide and no vanadium is produced as a joint product as is the case in ores worked in adjacent areas. This plant cannot be operated economically at less than 75 percent of capacity, and with the reduction in the AEC procurement program it is currently idle. Prospects for the future depend on numerous factors. At present the only market for uranium is the Federal Government, and its needs--primarily military--are pretty well saturated. Use for power generation depends on technological developments bringing down the price. It has been estimated that nuclear power will become an important source of electrical power by 1980. If so, this industry may again become important in the economy of the study area. The uranium industry was one of the largest water users in the area. In 1960, 184,000,000 gallons were used, or about 307 gallons per pound of concentrate produced.

The manufacturing component of this economy as a proportion of the total labor force has not changed significantly in the past twenty years, and remains materially less important than this activity is elsewhere as seen in Figure 4. Only 212 workers were employed in manufacturing in 1960. There were 28 establishments producing lumber and wood products only four of which employed 20 people or more, and 11 which produced food and kindred products, all of them quite small.

The share of employment in trade and services is comparable to that in the State and Nation. However, a study by the University of Colorado, Bureau of Business Research, indicated that nearly 15 percent of the retail spending by residents of the area is done at larger communities outside the region.

The region is somewhat off the main transportation routes. It is served by just one U. S. Highway, U. S. 40, which bisects the area in an east-west direction. This highway is not being made a part of the National Interstate and Defense Highway System. The Denver and Rio Grande Western Railroad has a spur line serving the eastern third of the area. This line, originally built as the Denver and Salt Lake Railway, follows the Yampa River to Steamboat Springs and has its terminus at Craig. It is the important link between the coal fields of the Upper Yampa and Denver, the major market for coal from this area. The D & RGW has been trying for some years to abandon passenger service on this line.

Recreation is an important and growing activity. Big game hunting here is among the Nation's best. Non-resident hunters in the area in 1960 came from all 50 states, Austria, Canada, and Mexico. They outnumbered resident big game sportsmen 5:1 in elk hunting and 8:1 in deer hunting. A total of 6,894 elk hunters and 28,002 deer hunters entered the area in 1960. The average seasonal expenditure for the non-resident hunter was: elk-\$387.50, and deer-\$295.67. For resident hunters the comparable expenditure was: elk-\$118.54, and deer-\$84.55. The total expenditure of people hunting big game in the area was \$5,643,959, of which \$2,548,736 was spent in the area, \$3,095,223 was spent outside the area. The total contribution to the area's economy in direct and indirect

flows was \$3,568,962. The number of visits to Dinosaur National Park increased from 10,928 in 1940, to 12,911 in 1950, to 37,000 in 1960 and 66,500 in 1962. Visits to White and Routt National Forests in the area were 19,600 in 1940, 119,000 in 1950, and 331,600 in 1960. Steamboat Springs calls itself Ski Town, USA, and has held a winter carnival for many years. Expansion of skiing facilities here is being actively promoted.

Future Economic Activities

Future development will center around the production of mineral fuels and recreation. The recent upturn in demand for coal of the region is likely to be sustained as electric power requirements increase and steam generation is called upon to bear an increasingly greater share of the load. The coal mining industry has become so highly mechanized, however, that this cannot be expected to increase labor requirements significantly. It is also likely that by 1980, the technology of nuclear power will have advanced to the point where this will become an important source of power for electricity generation, etc., and the uranium mining and processing industry in this area will also revive. Future prospects for growth in liquid petroleum production are less optimistic.

Another mineral fuel resource of the study area which could have an important impact upon future developments in the region is oil shale, the richest known deposits of which are along Piceance Creek within the study area. Planners currently pondering the prospective development of a shale oil industry, however, foresee the major population growth along the Colorado River Valley between Rifle and DeBeque, Colorado, which is outside the study area. The timing and magnitude of a shale oil industry is subject to a wide variety of opinions. Developmental work has been and is being done, but there are numerous imponderables involved. The present study assumes that the industry will develop on a moderate scale and pace.

The area has the mineral resources for a petrochemical industry based on petroleum, shale oil or coal and development of such an industry remains a distinct possibility, if not a probability.

Outdoor recreation, for which the area is abundantly endowed, will rapidly grow in importance as the population centers of the nation grow. Agriculture will remain important though employing a smaller share of the labor force. The recent development of these trends in recent years is seen in Figure 6.

Population Trends

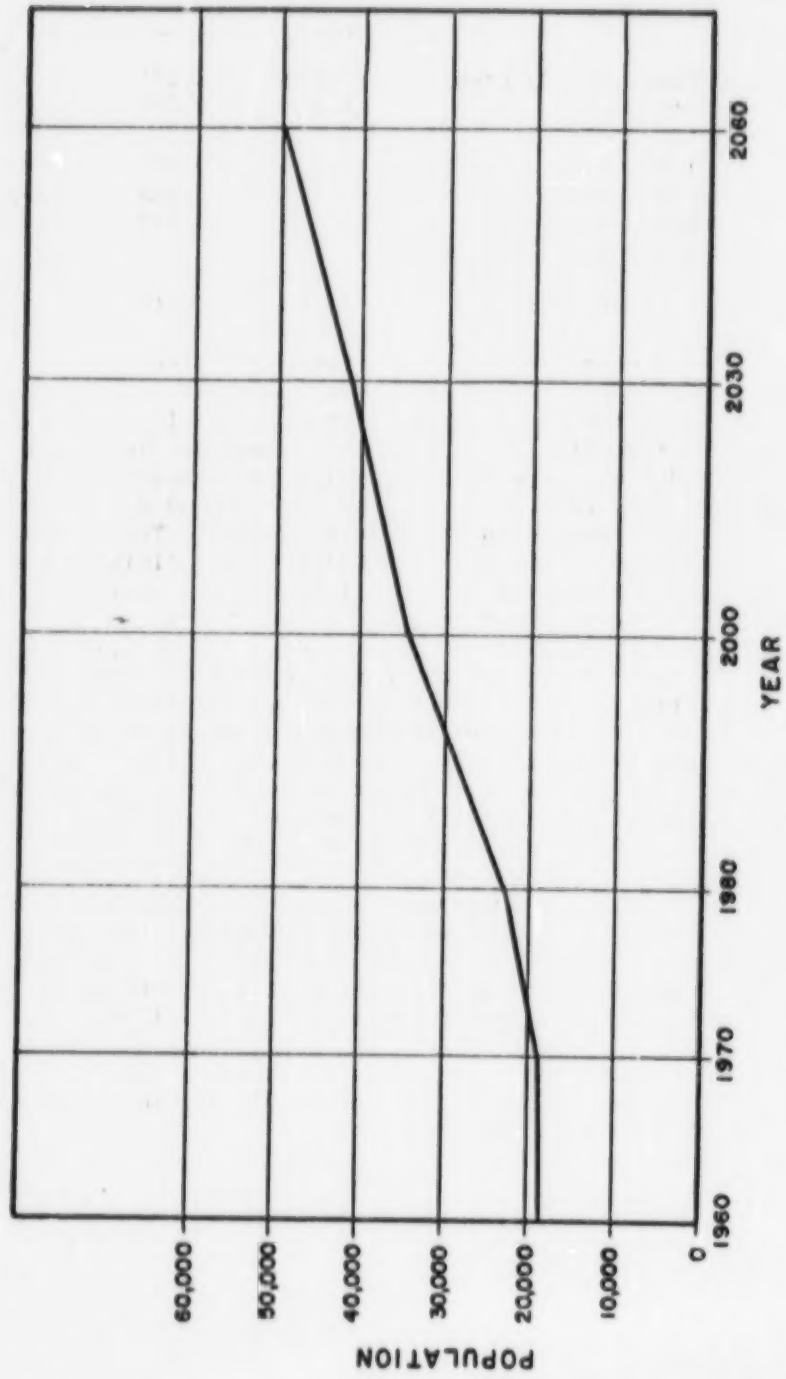
The total population of the area has changed very little in the past two decades as the following table indicates.

<u>Area</u>	<u>1930</u>	<u>1940</u>	<u>1950</u>	<u>1960</u>
Three-County Study Area	17,193	18,554	19,605	18,111
Moffatt County	4,861	5,086	5,946	7,061
Rio Blanco County	2,980	2,943	4,719	5,150
Routt County	9,352	10,525	8,940	5,900
Craig (town)	1,418	2,123	3,080	3,984
Meeker (town)	1,069	1,399	1,658	1,655
Rangely (town) -				
Not incorporated until - - 1946			808	1,464
Steamboat Springs	1,198	1,613	1,913	1,843

A substantial decrease in Routt County has offset increases in the other two counties. Growth in size of the towns has more than offset the population loss in the rural areas. Despite the slight absolute increase in the number of people in the area, the trend has been an outward movement. If we consider what the normal population increase would have been, based on the fertility rate, the area has experienced a net outmigration of more than 3,000 people in the 1950-60 decade. The area's share of the total population of the State of Colorado has diminished from 1.7 percent in 1940 to 1.5 percent in 1950 to 1.03 percent in 1960. The increased number of people in Rio Blanco County can be traced to the increased activity in the Rangely oil field since 1946, (a 1,332 percent increase in workers 1940-1960); and the decrease in Routt County population corresponds to decreasing employment in coal mining there (-83 percent in 1940-1960) and in both cases the accompanying impact on services, trade construction and transportation. All three counties of the area suffered significant declines in the number of people working in agriculture, an overall decline of 49 percent in the past two decades. A comparison of changes in population by age shows that the percentage of people of the dependent ages (under 14 and over 65) is increasing while the percentage in the 15-29 group is decreasing and that in the 30-45 age group remains about the same. This accords with the national trend.

It is not anticipated that there will be much change in this trend in the next few years (see Figure 7). There will be some impetus to growth as population growth elsewhere increases the recreational use of this area. A resurgence in the demand for uranium and coal for the generation of electric power in the 1980's should provide a further stimulus to growth in the area.

Figure 7
PROJECTED POPULATION GROWTH



VI. WATER QUALITY CONTROL

Under provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq), in the survey or planning of a reservoir by any Federal agency, consideration must be given to the inclusion of storage for regulation of streamflow for the purpose of water quality control. It is expressly stated that any such storage shall not be provided as a substitute for adequate treatment or other methods of controlling wastes at their sources.

Investigation of Pollution Sources

Investigation of water quality deterioration in the proposed Yellow Jacket Project area was separated into four classes, i.e., pollution resulting from municipalities, industrial activity, agricultural functions, and natural causes.

Since the Project involves both the White and the Yampa River Basins, consideration for each source of pollution was given on an individual basin basis.

A criteria of 5 mg/l as a minimum dissolved oxygen (DO) concentration was selected because game fish require at least this concentration for a healthy environment and because other factors such as recreational activity and aesthetic appearance require no more than 5 mg/l of DO. As field evidence indicated that the water temperature seldom raised above 20°C, this temperature was used in DO Calculations.

Steamboat Springs and Craig are the major contributors of domestic waste to the Yampa River. At present Steamboat Springs, population 1,850, treats its waste in an Imhoff tank while Craig, population 4,000, treats its wastes with primary sedimentation followed by lagoons. The present waste loading to the Yampa River causes no environmental health, recreational, or esthetic problems.

Calculations reveal that the projected waste loading for the year 2065 can be easily assimilated by the Yampa River. If the projected waste from Steamboat Springs and the other small towns will be treated such that 85% of the biochemical Oxygen Demand (BOD) is removed and if this waste is further reduced by the stream assimilation capacity of the Yampa River upstream from Craig, the daily BOD loading arriving at Craig will be 210 pounds. After adequate treatment, Craig will produce an additional 560 pounds per day. This daily loading of 770 pounds of BOD requires a flow of 9.5 cubic feet per second (cfs) below Craig in order to maintain dissolved oxygen (DO) concentration of at least 5.0 mg/l at a maximum water temperature of 20°C. The United States Geological Survey flow records for the station at Maybell, Colorado, 40 river miles below Craig, reveal that 95% of the time the flow in the Yampa River is equal to or exceeds 80 cfs; and 99.9% of the time the flow equals or exceeds 9.5 cfs.

The gaging station located at Steamboat Springs, Colorado, 65 miles upstream from Craig, indicates that during low flow periods the flow at this station and Maybell is about the same. For this reason the flow data from Maybell, although 40 miles below Craig, was considered as representative of the flow at Craig for critical flow periods.

Pollution of the Yampa River by industrial sources is minimal. The uranium processing mill located at Maybell has not been in operation for more than a year, and future operation seems remote. There is a possibility of leaching some soluble salt and radioactive materials from a tailings pile which remained after production was terminated. There is evidence that wind erosion is responsible for transporting some of this material to areas where it can be washed into the Yampa. However, preventing this problem is the responsibility of the industry and providing dilution flow has not been considered.

Total Dissolved Solids pollution of the Yampa River Basin was found to be limited to a natural leaching associated with runoff. No major mineral springs were located in or near the Project area.

The domestic waste situation in the White River Basin is nearly the same as the Yampa Basin. Meeker, with a population of 1,650, treats two-thirds of its waste in a recently constructed mechanical aeration plant, while slightly over 500 residents still use septic tanks which discharge into the ground. The plant at Rangely which serves 1,200 persons consists of an Imhoff tank. In projecting the BOD loading of adequately treated waste from Meeker for the year 2065, it was found that the White River must be able to assimilate 270 pounds of BOD daily. To accommodate this waste under critical conditions, i.e., at a water temperature of 20°C and a minimum of 5 mg/l DO, it is necessary to maintain a flow of 4 cfs in the river. The U. S. Geological Survey station at Meeker provides 60 years of flow records and in this period the minimum flow was 112 cfs.

Industrial pollution of the White River is primarily limited to that which is a result of oil production at Rangely. However, all the oil produced is exported as crude oil and refined elsewhere and only drilling and pumping activities remain. The assimilative capacity of the river is great enough to handle all present or projected adequately treated organic waste contributed by this industry.

Future industrial pollution of the White River is largely dependent upon the development of the shale oil industry. Piceance Creek Basin, which is a few miles west of Meeker, contains the richest and most accessible deposits of oil shale and as a result of these rich deposits near the Yellow Jacket Project, the Bureau of Reclamation has received many inquiries concerning the possibility of obtaining water for developing an oil shale industry in the Piceance Creek Basin. It seems highly probable that mining operations, retorting, and product refining will take place within the White River Basin. It is impossible to determine the extent to which the shale oil industry will produce waste, but it should

be understood that measures must be taken to restrict pollution of an organic, settleable solids, or dissolved solids nature, which will be characteristic of the industry.

Mineral pollution of the White River is caused by runoff from highly saline areas and by mineral springs. Under the Project area lies an artesian aquifer bearing a warm mineralized water which allows seepage of highly saline water to the surface. Piceance Creek Basin, which is located 25 miles below Meeker, is an example of such an area. Field reconnaissance to the basin showed that at times the flow from Piceance Creek has a TDS ranging from 3,500 to 7,000 mg/l. Samples from wells in the basin reveal that the TDS is often as high as 3,400 mg/l. A number of oil wells have penetrated this artesian aquifer and have later been abandoned. An effort has been made to seal some of these wells but the effectiveness of these measures is questionable. It is necessary to plug these wells in the impervious strata just above the aquifer or else the saline water will recharge a permeable strata nearer the surface and eventually pollute surface waters. An example of a polluting saline source is Meeker Spring.*

Meeker Spring, located on the White River four miles east of Meeker, discharges approximately 160 tons of TDS per day into the river. With this load and with the mean discharge of 628 cfs of the White River at Meeker, the TDS concentration of the White River is increased 95 mg/l at Meeker. The damage to present and potential water users caused by this type of pollution is as real as any biodegradable pollution.

Agricultural activity of the proposed project was considered as a possible source of TDS pollution. The problem was approached on two bases to give a likely range in which the actual TDS value will fall. The first method termed as "one to one salt balance" gives the lower limit and considers only the salts applied to the field during irrigation. All of these salts and only these salts are removed via irrigation returns. In using the one to one salt balance, the TDS concentration will increase due to evaporation and transpiration losses; however, no increase in the total load will result. The second approach is much more realistic and gives the upper limit of TDS pollution. This method, referred to as "leaching conditions," takes into account that leaching of native minerals from the irrigated lands will occur. This results not only in a TDS concentration increase but also in a total salt load increase.

The TDS pickup due to leaching is estimated to be two tons per irrigated acre. This figure is arrived at by considering two factors. The

*This is not an actual spring but has recently been identified by local residents as an abandoned well and thus is classified as an industrial source of pollution.

first factor is a comparison of the historical increments of TDS and water contributed to the river in the Project area. Extrapolating by means of these increments an additional leached salt load was estimated to be 2.1 tons per irrigated acre. The second factor considered was the study conducted by the Bureau of Reclamation* on the Eden Project which is 170 miles northwest of the Yellow Jacket Project and located on a similar geologic formation. This study reveals that two tons of TDS per irrigated acre is contributed by the Project.

Considering a one to one salt balance, the average TDS concentration in the Yampa River will increase from 139 mg/l to 140 mg/l as a result of an annual water loss of approximately 8,000 AF per year. However, when leaching of soluble minerals from the irrigated soil is considered, the average TDS concentration in the Yampa River at Maybell, Colorado, is expected to increase from 139 mg/l to 147 mg/l, about 6%. The major cause for this increase is the leaching of 10,000 tons of solids a year from 5,400 acres of irrigated land.

In applying the one to one salt balance to the White River Basin, an average increase in TDS from 439 to 469 mg/l is expected at Watson, Utah. However, when leaching of the 23,200 acres occurs, an expected 45,000 tons per year is expected. This results in nearly a 14% increase in the soluble solids loading to the river; and when combined with the evapotranspiration water losses, the average TDS concentration at Watson, Utah, will increase from 439 mg/l to 533 mg/l, a 21% increase.

The combined TDS loading increases and water losses of the Yampa and White Rivers will change the average concentration in the Green River at the U. S. Geological Survey station at Ouray, Utah. With the one to one salt balance the change will be from 392 to 396 mg/l and with leaching considered the change will be from 392 to 405 mg/l. Figure 8 shows these changes.

Damage Caused by Pollution

As the primary beneficial water use in the Yampa River Basin is for irrigation and the projected increase in TDS is within the tolerance limits of these irrigated crops, the damage is indefinable. Inasmuch as the town of Rangely, Colorado, takes its domestic water supply from the White River below the Project lands, damages resulting from mineral increases were investigated.

*Quality of Water Colorado River Basin Progress Report, January 1965, U. S. Department of the Interior, Geological Survey.

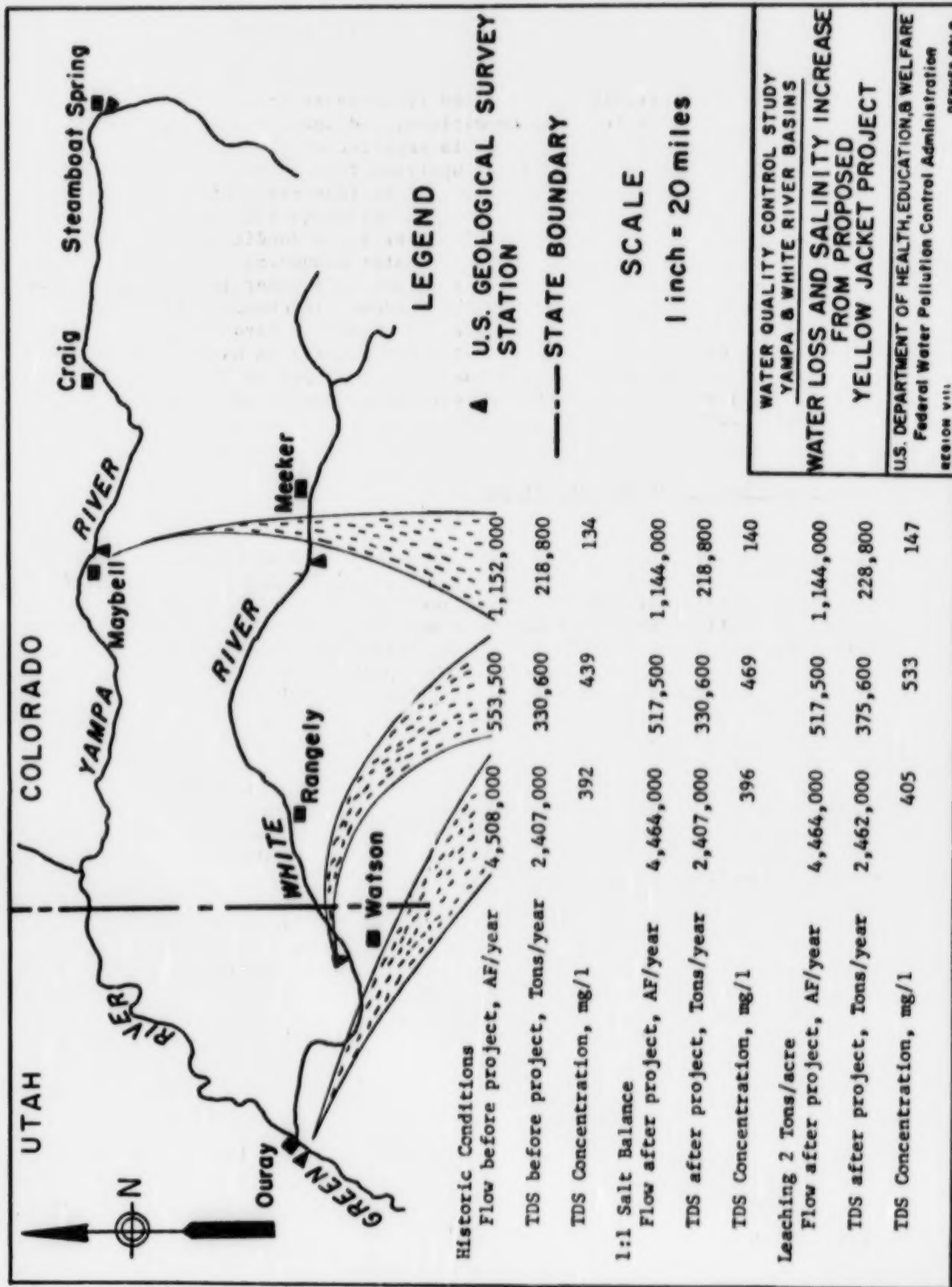


FIGURE 8

The TDS concentration is expected to increase from 439 mg/l to 533 mg/l at Rangely under leaching conditions, and under one to one salt balance conditions the TDS increase is expected to be from 439 mg/l to about 469 mg/l (although Rangely is upstream from Watson, the mineral concentrations are not expected to change in this reach of stream). Since there are no other water sources of better quality available, a water with 533 mg/l TDS is acceptable under these conditions according to U. S. Public Health Service Drinking Water Standards 1962. Hardness is expected to increase from 202 mg/l to 245 mg/l under leaching conditions and with a one to one salt balance the hardness is expected to increase from 202 mg/l to 216 mg/l. The 43 mg/l increase in hardness will result in a present day damage to the domestic water users in Rangely of \$1,300 per year and in the year 2065 a damage of \$3,400 per year. The 14 mg/l increase will result in a \$400 per year damage and in the year 2065 a damage of \$1,000 per year.*

Effect of Removal of Meeker Spring

Since Meeker Spring is responsible for a substantial portion of the mineral pollution in the White River Basin, removal of the spring was considered as a beneficial Project feature. If the TDS contribution of the spring were eliminated by the Project, the net TDS change under Project conditions when considering a one to one salt balance would be a reduction of 42 mg/l at Watson, Utah. With leaching considered, the net TDS concentration change without the spring is only a 22 mg/l increase rather than a 94 mg/l increase. See Table II. With the hardness contributed by the spring removed, the hardness in the White River at Rangely would be reduced 11 mg/l. An 11 mg/l reduction in hardness, with the present population, would result in a savings of \$300 per year both without the Project and with the Project under any salt load. With the population projected for 2065, the savings would be \$900 a year under the same conditions. See Table III. An additional savings could result for Meeker since Meeker may no longer have to maintain a municipal supply intake line to a point upstream of the spring.

Streamflow regulation within the White River Basin could be used to improve quality during periods of low flow, but would not improve the average annual mineral quality. In order to offset the change in water quality due to Project development, it would be necessary to import better

*Based on data from "Economics of Water Softening", by Louis K. Howson, Journal of the American Water Works Association, February 1962, and "Water Hardness and Domestic Use of Detergents", by Lloyd M. DeBoer and Thurston E. Larson, Journal of the American Water Works Association, Vol. 53, July 1961, No. 7.

TABLE II
Comparison of Projected Total Dissolved Solids Concentration
in Surface Waters

	TDS in Yampa River near Maybell, Colorado, mg/l*		TDS in White River near Watson, Utah, mg/l*		TDS in Green River near Ouray, Utah, mg/l*	
	with Meeker Spring	without Meeker Spring	with Meeker Spring	without Meeker Spring	with Meeker Spring	without Meeker Spring
Pre Project		139	439	362	392	383
One to One Salt Balance		140	469	397	396	386
Leaching by Project		147	533	451	405	395

*Concentrations are flow weighted mean.

TABLE III
Comparison of Damage Caused by Hardness
Rangely, Colorado

	Hardness in White River at Rangely** mg/l as CaCO ₃		Benefits resulting from Project Operation in 1965***		Benefits resulting from Project Operation in 2065***	
	with Meeker Spring	without Meeker Spring	with Meeker Spring	without Meeker Spring	with Meeker Spring	without Meeker Spring
Pre Project	202	191		+\$300		+\$900
One to One Salt Balance	216	205		-\$100		-\$100
Leaching by Project	245	234		-\$1300		-\$2500

* Concentrations are given as flow weighted mean since they do not vary much from average concentrations.

** Data figures calculated for Watson but the river does not change in quality significantly between the two towns.

***Based on cost of \$2.00 per person per 100 mg/l hardness (11, 12).

quality water into the basin. Since streamflows are adequate at all times to assimilate any present or projected organic waste, and since flow regulation for mineral quality control would be ineffective within the basin, inclusion of storage for water quality control purposes would have minimal value.

This is not to preclude the possibility that a need for regulation of streamflow for the purpose of water quality control will become apparent when comprehensive studies of the Colorado River Basin have been completed. These studies should establish the magnitude of the cumulative effect on water quality of the many projects being planned and constructed by the Bureau of Reclamation and others, or the possible cumulative improvement in the quality of the Colorado River which might be derived from the integrated operation of storage provided for flow regulation in all of these reservoirs. Until such studies have provided more definitive data, however, recommendations cannot be made.

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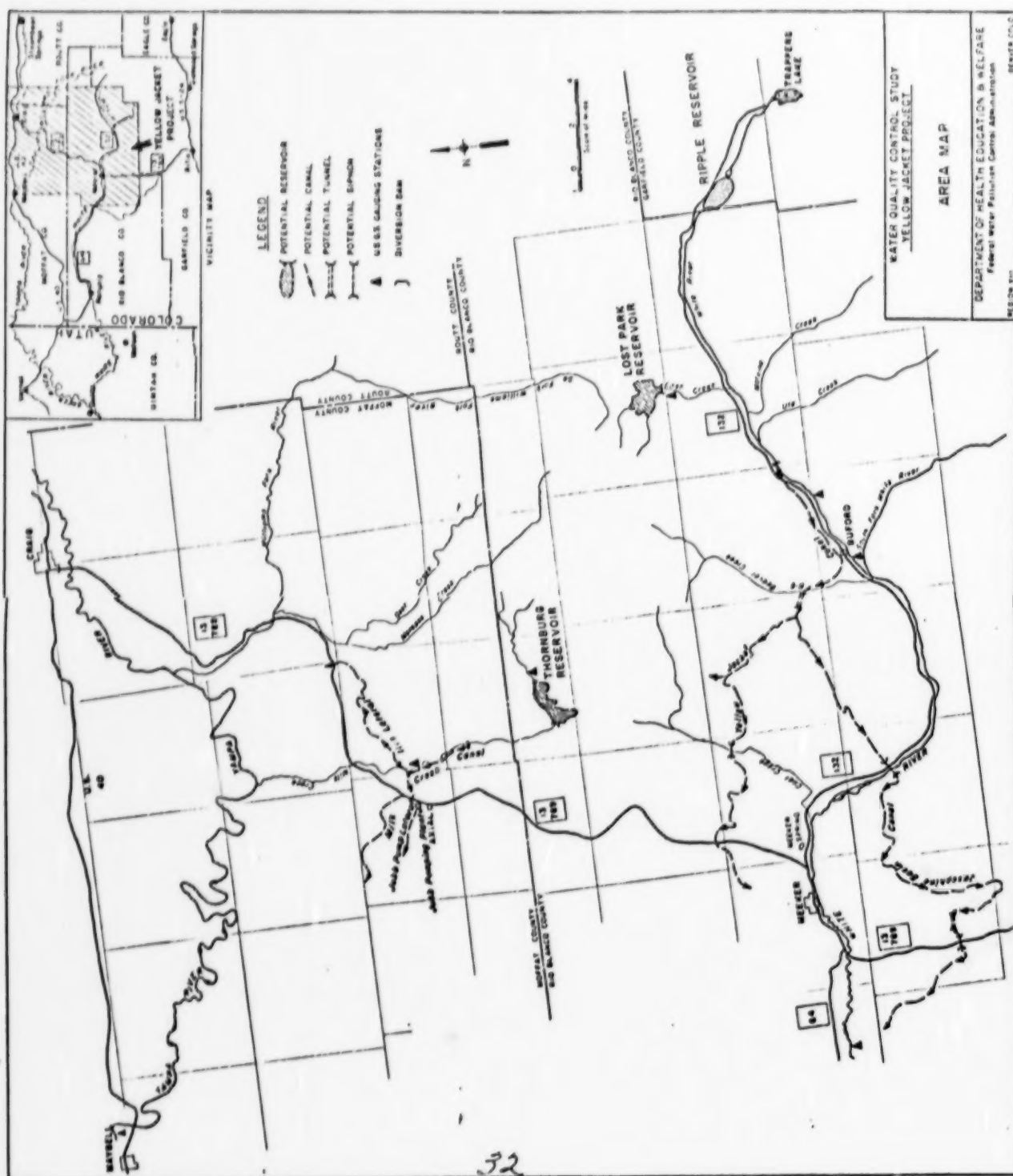


FIGURE 1